2nd Generation Magnets for an IR upgrade

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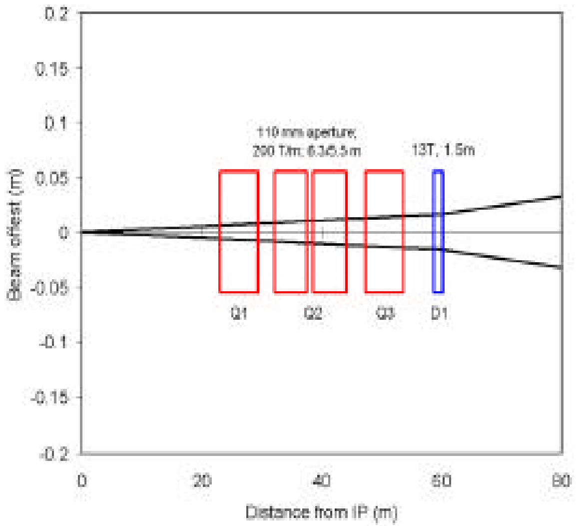
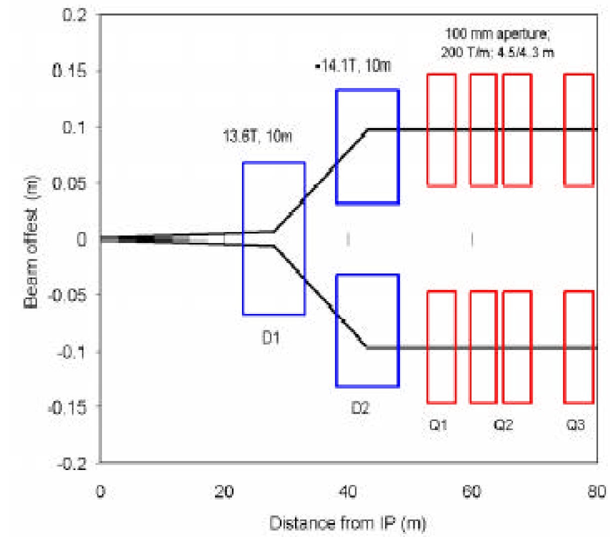
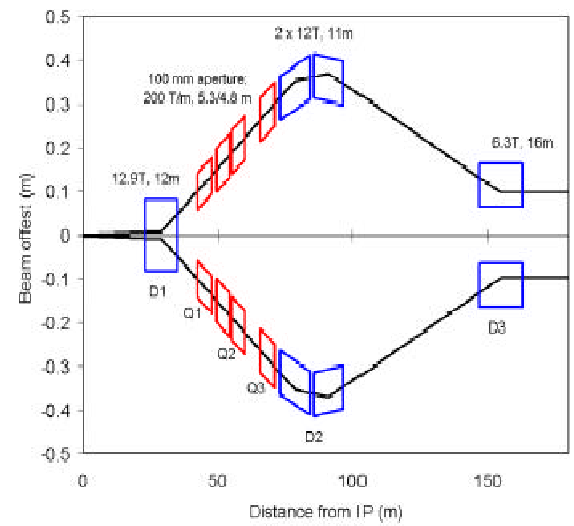
FNAL

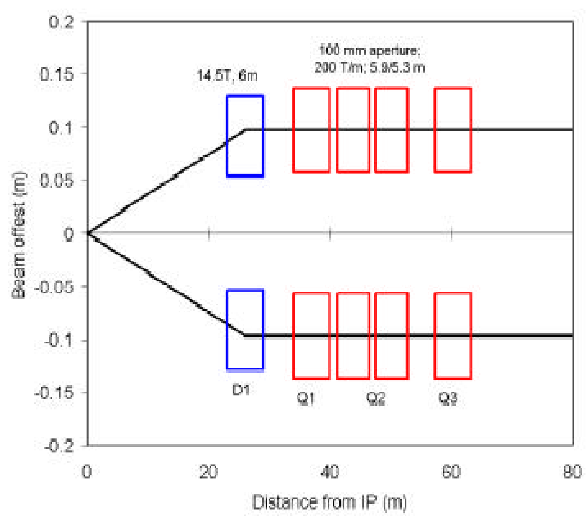
- Quadrupoles first layout
- Dipoles first layout
- Sequence of upgrades

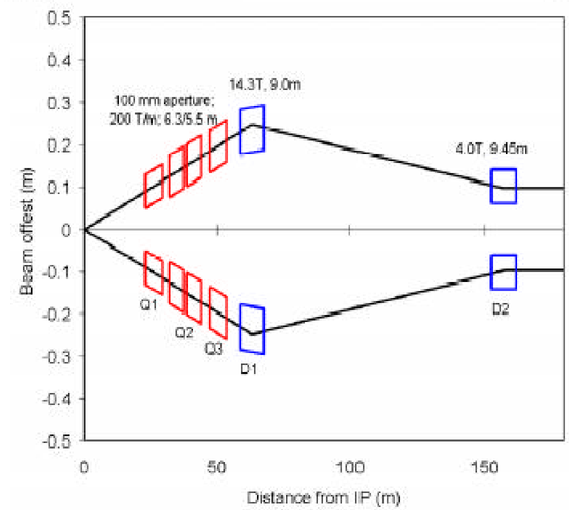
Different IR Layouts











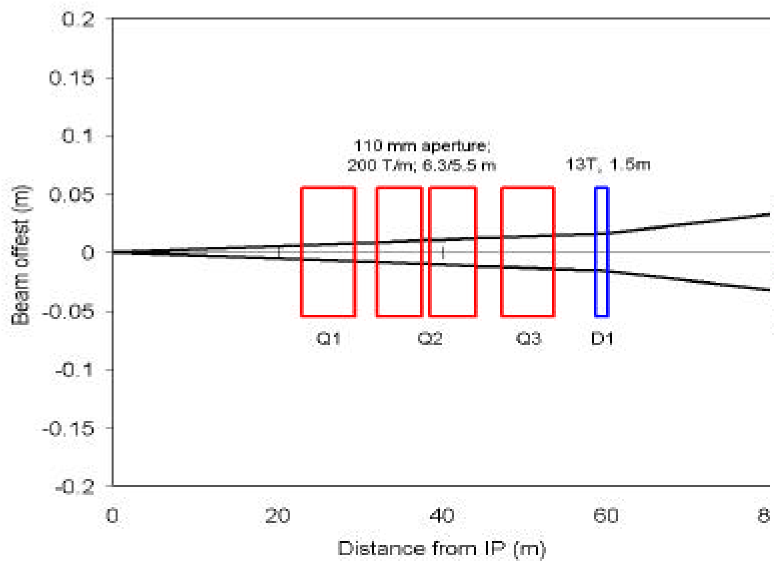
Basic Parameters

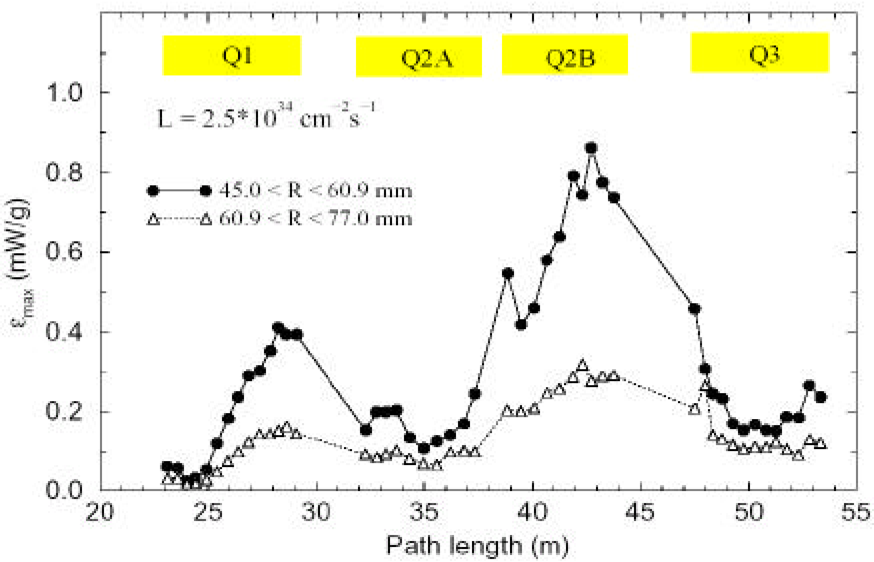
Table 1: IR Parameters

	Base-line	Quad 1st	Dipoles 1st	Quad between	Twin D 1st	Twin Q 1st
IP to Q1 (m)	23	23	52.8	42.5	34	23
D_{quad} (mm)	70	110	100	100	100	100
β^*_{min} (cm)	50	16	26	19	15	10
β_{max} (km)	5	15	23	23	23	23
B_{D1} (T)	2.75	15.3	15	14.6	14.5	14.3
L_{D1} (m)	9.45	1.5	10	12	6	9
D_{D1} (mm)	80	110	135	165	75	105

J. Strait et al, PAC03

Challenges with Quadrupoles first





- **Accelerator physics**

  - Several beam-beam interactions: experience will show if they have a significant effect. Alternative: wire compensation shown to work.

  - Nonlinear correction for both beams

- **Energy deposition**

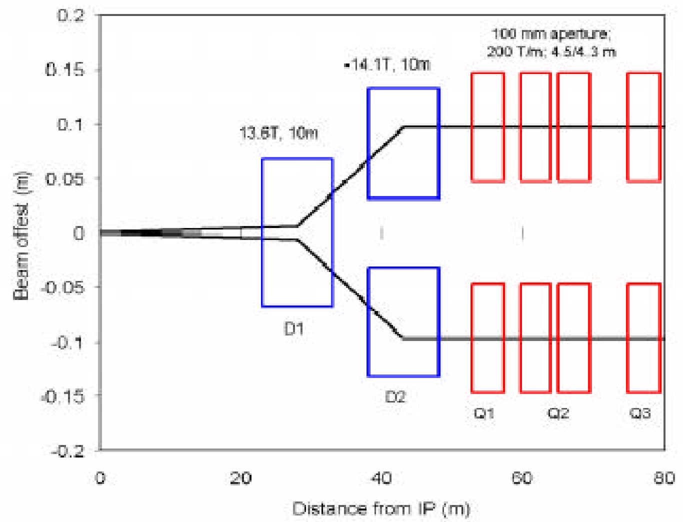
  - peak power above known quench limits. E_{max} > 4 mW/g at L= 10^{35} cm^{-2} s^{-1}

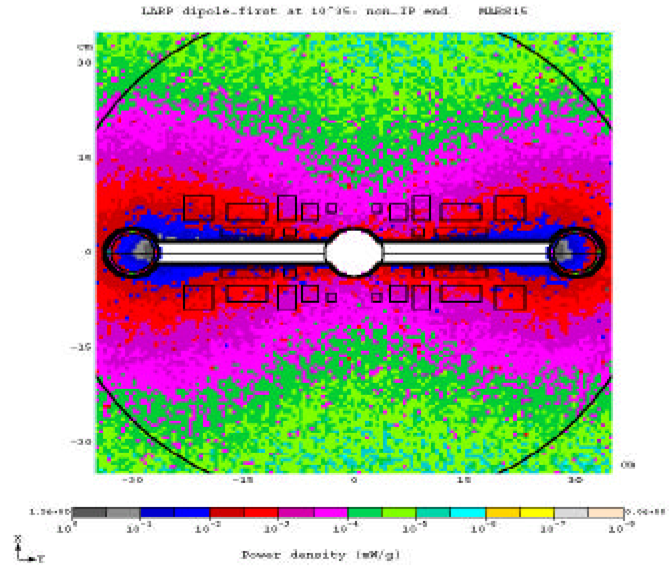
- **Magnet design**

  - accelerator quality, large aperture (100mm) quads have to be built

  - radiation hard materials need development

Challenges with dipoles first





- **Accelerator physics**

  - large beta functions in the quads – requires good field quality

- **Energy deposition**

  - problem is most severe, about 3.5kW of beam power deposited in dipoles at luminosity =10 ^{35} cm^{-2} sec^{-1}

- **Magnet design**

  - build an accelerator quality open midplane D1 dipole
  - build a dual aperture D2 dipole with good field quality

Upgrade with NbTi

Table 2: 'Large bore' baseline option: triplet quadrupole lengths and apertures for $\beta^* = 0.25$ m compatible with the NbTi gradient limit (lower curve in Fig. 1).

quad	length m	gradient at 7 TeV T/m	coil aperture mm
Q1	6.0	275	53
Q2	7.4	197	85
Q3	7.8	196	82

"… the choice of coil aperture is driven more by the power density than by the beam acceptance"

F. Ruggiero et al, EPAC2004

"… limitations due to heat deposition not taken into account"

Quad-first IR with $\beta^* = 16$ cm

- Nb_3Sn: length = 6m, aperture = 110 mm
- NbTi: estimate length ~ 8-9m, aperture ~120-130 mm
- =>~30% increase in β_{max}; 15~20% more parasitic collisions.

Current NbTi technology is not sufficiently radiation hard.

Smaller temperature margin => more sensitive to beam heating.

And dipole-first IR requires highest possible field: => requires Nb_3Sn

Sequence of upgrades

Very likely that there will be several upgrades - a possible sequence

- Quadrupoles first layout - Modest upgrade with NbTi magnets
- Quadrupoles first layout - Some magnets replaced with Nb_3Sn magnets
- Dipoles first layout - Nb_3Sn dipoles and quadrupoles, crossing angles < 0.5 mrad
- Large crossing angles ~8mrad, crab cavities